

Non-Parametric tests

Introduction to non-parametric tests

- Non-parametric tests in biostatistics are essential when data do not meet the assumptions of parametric tests—such as normal distribution or equal variances.
- These tests are often called distribution-free tests because they do not assume a specific statistical distribution.

Characteristics of Non-Parametric Tests

1. Distribution-Free

- No assumption about the underlying data distribution (e.g., normality).

2. Robust to Outliers

- Less sensitive to extreme values compared to parametric tests.

3. Applicable to Various Data Types

- Can be used with ordinal, nominal, and interval data, especially when the data are not normally distributed.

4. Use of Ranks

- Many non-parametric tests rely on data ranks rather than actual values, reducing sensitivity to non-normality and outliers.

5. Effective for Small Sample Sizes

- Particularly useful when the central limit theorem does not apply due to small sample sizes.

Advantages of Non-Parametric Tests

1. **Flexibility:** Applicable to skewed, ordinal, and nominal data—common in biostatistics.
2. **Minimal Assumptions:** No need for assumptions such as normal distribution or equal variances.
3. **Useful for Small Samples:** Ideal for early-phase clinical trials or research on rare diseases with limited data.

Disadvantages of Non-Parametric Tests

1. **Less Powerful than Parametric Tests:** Lower statistical power when data actually meet parametric test assumptions.
2. **Limited Interpretation:** Often provide results related to medians or ranks rather than means, which may limit interpretation.
3. **Complexity in Multivariable Analysis:** Non-parametric approaches for multivariable data exist but tend to be more complex and less straightforward.

Common Non-Parametric Tests and Their Procedures

1. Mann-Whitney U Test

- **Purpose:** Compare two independent groups.
- **Procedure:** Rank all observations together. Compute the U statistic to determine if there is a significant difference between groups.

2. Wilcoxon Signed-Rank Test

- **Purpose:** Compare two related samples.
- **Procedure:** Calculate differences for each pair, rank the absolute differences, assign original signs to ranks, and evaluate the sum of ranks to test for median differences.

3. Kruskal-Wallis Test

- **Purpose:** Compare more than two independent groups.
- **Procedure:** Rank all data across groups and compute the H statistic to test for group differences.

4. Friedman Test

- **Purpose:** Compare more than two related groups.
- **Procedure:** Rank treatments within each block (e.g., subject), then analyze differences using the Friedman statistic.

5. Spearman's Rank Correlation

- **Purpose:** Assess the strength and direction of association between two ranked variables.
- **Procedure:** Rank both variables and compute the Spearman correlation coefficient.

Usage in Biostatistical Research

1. **Skewed Data:** Biological measurements often exhibit skewed distributions (e.g., hormone levels, enzyme concentrations).
2. **Ordinal Data:** Many outcomes in medicine and biology are ordinal (e.g., pain scores, cancer stages).
3. **Small Sample Sizes:** Common in early-stage studies or research involving rare conditions where parametric assumptions may not be valid.

Wilcoxon Rank Sum Test & Wilcoxon Signed-Rank Test

- The Wilcoxon Rank Sum Test and the Wilcoxon Signed-Rank Test are important non-parametric statistical methods.
- **These are particularly useful when:**
 - The assumptions of parametric tests (like normality and equal variance) do not hold.

- Data are ordinal, skewed, or from small samples.
- Common applications include medical and biological research, such as clinical trials or ecological studies.

Wilcoxon Rank Sum Test (for Two Independent Samples)

- Also known as the Mann-Whitney U test, this test is used to compare two independent groups when data are not normally distributed.

Use Case:

- Comparing the effects of two treatments on a continuous but skewed or ordinal outcome.

Steps to Perform the Wilcoxon Rank Sum Test:

1. Combine and Rank the Data:

- Combine all observations from both groups and rank them from smallest to largest.
- In case of ties, assign average ranks.

2. Calculate Sum of Ranks:

- Let the sum of ranks for group 1 be R_1 and for group 2 be R_2 .

3. Compute the Test Statistic:

$$U_1 = R_1 - \frac{n_1(n_1 + 1)}{2}$$

$$U_2 = R_2 - \frac{n_2(n_2 + 1)}{2}$$

- Where n_1 and n_2 are the sample sizes.
- The test statistic U is the **smaller** of U_1 and U_2 .

4. Determine the P-value:

- Use statistical tables or software. For large samples, a **normal approximation** may be used.

5. Interpret Results:

- If **p-value < significance level** (e.g., 0.05), reject the null hypothesis.
- This suggests that the two populations do not have the same distribution.

Wilcoxon Signed-Rank Test (for Paired Data)

- Used when the data are paired (e.g., before-and-after measurements or matched pairs in a case-control study).

Steps to Perform the Wilcoxon Signed-Rank Test:

1. Compute Differences:

$$D_i = X_i - Y_i$$



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